Antarctic UV Spectroradiometer Monitoring Program: Contrasts in UV Irradiance at the South Pole and Barrow, Alaska

C. R. BOOTH, T. B. LUCAS, J. R. TUSSON IV, J. H. MORROW, AND T. MESTECHKINA
Biospherical Instruments Inc., San Diego, California 92110-2621

INTRODUCTION

The Antarctic ultraviolet spectroradiometer monitoring network was established by the U.S. National Science Foundation (NSF) in 1988 in response to predictions of increased UV radiation in the polar regions. The network consists of several automated, high-resolution spectroradiometers; five are placed in strategic locations in Antarctica and the Arctic (Table 1), and one is established in San Diego to collect data and serve as a training and testing facility. The network makes essential measurements of UV spectral irradiance and provides a variety of biological dosage calculations of UV exposure. Biospherical Instruments Inc., under contract to Antarctica Support Associates (ASA), directed by NSF, is responsible for operating and maintaining the network and distributing data to the scientific community.

The spectroradiometers used in the system are Biospherical Instruments, Inc. model SUV-100. Each instrument contains an irradiance diffuser, a double-holographic grating monochromator, a photomultiplier tube, and calibration lamps. A vacuum-formed Teflon diffuser serves as an all-weather irradiance collector, and it is heated by the system to deter ice and snow accumulation. Tungsten-halogen and mercury-vapor calibration lamps are used for automatic internal calibrations of both responsivity and wavelength that occur two to four times daily. All instrument functions, calibration activities, and data acquisitions are controlled by an MS DOS-compatible computer. Further details on the spectroradiometers can be found in *Booth et al*. [1994].

UV RADIATION CLIMATE AT THE AMUNDSEN-SCOTT SOUTH POLE STATION, AND BARROW, ALASKA

The South Pole and Barrow, Alaska, installations of the network are in locations that also have CMDL installations. Therefore, the balance of this report will focus on these two sites. The South Pole site is uniquely suited to examinations of radiative transfer including the effects of ozone on UV radiation. This site is located away from the influence of mountains in a region of almost constant albedo. Cloud cover is relatively infrequent and it is generally thin when it does occur. The very small hourly change in the solar zenith angle at the South Pole supports examination of changes in total column ozone (as estimated by UV irradiance) at hourly resolution.

Barrow can be contrasted with the South Pole in that it is located where a significant change in surface albedo occurs because of both the springtime snowmelt [*Dutton and Endres*, 1991] and changes in sea-ice coverage. Also, Barrow experiences significant changes in incident irradiance because of Arctic storms. The contrast in irradiances between Barrow and the South Pole can be seen in Figure 1*b*, which depicts the integrated noontime irradiances over the UV-A spectrum (320-400 nm) from January 1992 through December 1993.

The large changes in total-column ozone encountered at the South Pole make it an ideal site to examine the relationship between ozone depletion and enhanced UV irradiance. For example, in Figure 1*a*, a substantial *decrease* is seen in the 300 nm irradiance around

TABLE 1. Installation Sites

Site	Latitude	Longitude	Established	Location
South Pole	90.00°S	0°	February 1988	Clear Air Building
McMurdo	77.51°S	166.40°E	March 1988	Arrival Heights
Palmer	64.46°S	64.03°W	May 1988	Clean Air Building
Ushuaia, Argentina	54.49°S	68.19°W	November 1988	CADIC*
Barrow, Alaska	71.18°N	156.47°W	December 1990	UIC-NARL**
San Diego, California	32.45°N	117.11°W	October 1992	Biospherical Instruments Inc.

*CADIC: Centro Austral de Investigaciones Cientificas, Argentina.
**Ukpeagvik Inupiat Corporation-National Arctic Research Laboratory

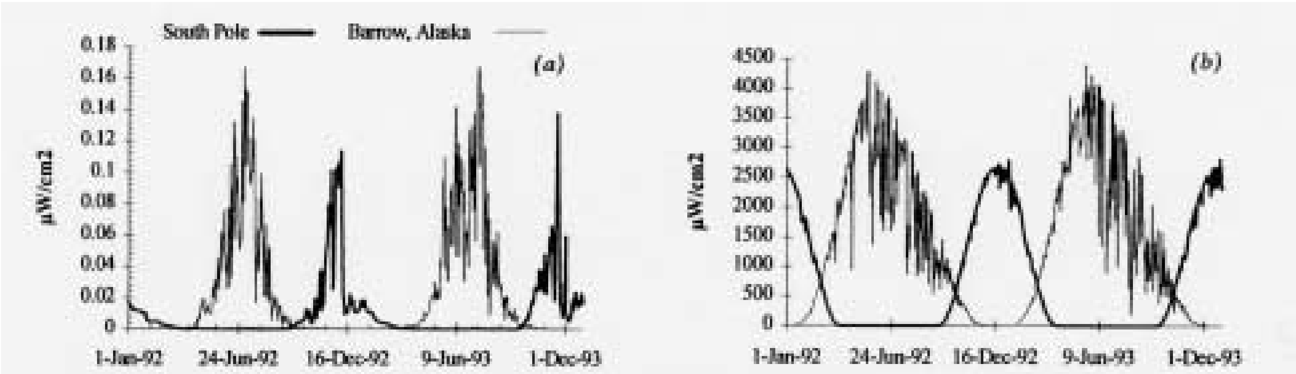

Fig. 1. Noontime irradiance at Barrow, Alaska, and the South Pole from January 1992 through December 1993. Panel *a* (left) shows the irradiance at 300 nm and is contrasted with panel *b* (right) that illustrates the integrated UV-A (320-400 nm) irradiance. The higher irradiance values at Barrow are due to the higher sun elevation. Note that the irradiances at Barrow peak in June, while the irradiances at the South Pole normally peak in December.

December 6, 1992. Meanwhile, Total Ozone Mapping Spectrometer (TOMS Nimbus-7) data report that the ozone column over the South Pole *increased* from 193 DU on December 5 to 292 DU on December 7, 1992. Similarly, a substantial *increase* in the 300 nm irradiance occurred between November 15 and November 20, 1993. As shown in Figure 2, this rise corresponded with a *decrease* of approximately 70 DU in the TOMS data.

By comparing the strongly depleted, springtime ozone levels over the Pole with the higher ozone levels observed at summer solstice, observations can be made regarding the impact of changes in ozone on UV irradiance - most other conditions (i.e., cloud cover, albedo, and solar zenith angle) being equal. Figure 2 contrasts integrated UV measurements with data from the TOMS satellite and corresponding solar zenith angles for September through December of 1993. As expected, ozone concentration and UV appear to be inversely correlated. Notice that as the season progressed toward summer solstice in December, the increase in solar angle (i.e., decrease in solar zenith angle) and small decreases in ozone resulted in a dramatic increase in UV (i.e., "radiation amplifica-tion"). Evaluation and calculation of the exact amplification factor of ozone on UV are described in *Madronich* [1993] and in *Booth and Madronich* [1994].

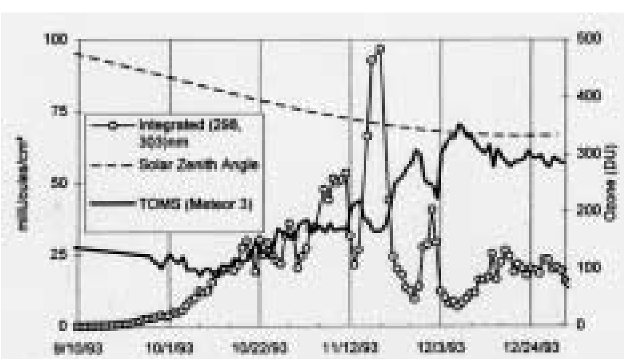

Fig. 2. Daily flux in milliJoules cm^{-2} integrated over the spectral region of 298 to 303 nm at the South Pole during the spring of 1993. Also shown is the Nimbus-7 TOMS reported total column ozone values in DU. TOMS data courtesy of Rich McPeters of GSFC, NASA.

SUMMARY

High spectral resolution scanning UV spectro-radiometers were established at six sites and are successfully providing multi-year data sets. Resulting data were used to test radiative transfer models [*Lubin and Frederick*, 1990, 1991, 1992; *Lubin et al.*, 1989, 1992; and *Smith et al.*, 1991, 1992*a*, *b*, *c*], derive ozone concentrations [*Stamnes et al.*, 1990, 1991, 1992], and examine the biological impact of enhanced UV [*Lubin et al.*, 1992; *Cullen et al.*, 1992; and *Smith et al.*, 1991, 1992*b, c*; *Setlow*, 1974].

The data discussed here and all other data recorded by the NSF UV monitoring network are available to all qualified researchers. The data are divided into three classes. Level 1 data are in their original, uncorrected binary form and level 2 data were referenced to beginning-of-season calibration constants. These two classes are available only to NSF-sponsored researchers upon special request. Level 3 data are referenced to both beginning- and end-of-season calibration constants. These data are distributed on CD-ROM and are available to any researcher. For more information, please contact: C.R. Booth at Biospherical Instruments Inc., 5340 Riley St., San Diego, CA 92110 (Fax: (619) 686-1887, or Internet: booth@biospherical.com).

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Programs. B. Mendonca of CMDL assisted in providing operators and support for the installations at Barrow. R. McPeters of NASA/GSFC provided TOMS Total Ozone data for comparison purposes. TOMS Update CD-ROM is available from the National Space Science Data Center (NSSDC), Goddard Space Flight Center. Barrow operators include D. Norton (Arctic Sivumnun Ilisagvik College), D. Endres and B. Halter (CMDL). The Ukpeagvik Inupiat Corporation of Barrow provided assistance in the installation. Operators at Palmer and McMurdo were provided by ASA. Special thanks go to John Gress of ASA who has been invaluable in the operation of the network.

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